CALCULATING FENESTRATION PRODUCT PERFORMANCE IN WINDOW 6 AND THERM 6 ACCORDING TO EN 673 AND EN 10077

1.1. Overview

EN/ISO 10077 set of standards (10077-1 and 10077-2) give procedure how to calculate center of glazing and whole fenestration product thermal and solar-optical performance.

- EN/ISO 10077-1: Calculations for
  - Center-of-glazing (references ISO 10292 (EN 673))
  - Whole product performance
- EN/ISO 10077-2: Calculation of thermal performance for
  - Frame
  - Edge of glazing area

1.2. MODELING IMPLEMENTATION:

1.2.1. WINDOW -- Center of Glazing

Preferences:

Center-of-glazing calculations are done in WINDOW 6 by setting the preferences to EN 673/ISO 10292. Go to the File/Preferences menu choice, and then the Options tab in the Preferences screen. Under Thermal calculation options, set it to “EN 673”

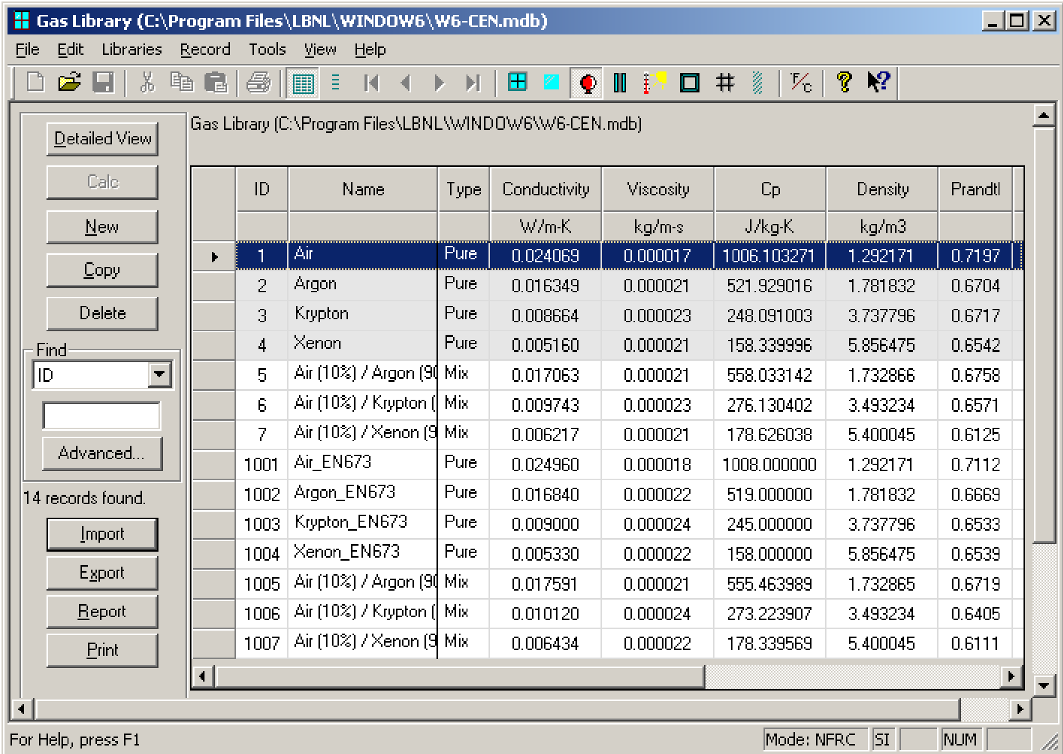
Special Gas Library:

There is a special WINDOW Gas Library (called “EN673 gasses.mdb”) to be used with the EN 673 standard, available on the WINDOW Knowledge Base website (http://windows.lbl.gov/software/window/6/).

These gases can be imported into the WINDOW Gas Library using the import button and browsing to this database. Below is a list of the gases in this library.

- Air_EN673
- Argon_EN673
- Krypton_EN673
- Xenon_EN673
- Air (10%) / Argon (90%) Mix EN

- Air (10%) / Krypton (90%) Mix EN
- Air (10%) / Xenon (90%) Mix EN



ID	Name	Type	Conductivity	Viscosity	Cp	Density	Prandtl
			W/m-K	kg/m-s	J/kg-K	kg/m3	
1	Air	Pure	0.024069	0.000017	1006.103271	1.292171	0.7197
2	Argon	Pure	0.016349	0.000021	521.929016	1.781832	0.6704
3	Krypton	Pure	0.008664	0.000023	248.091003	3.737796	0.6717
4	Xenon	Pure	0.005160	0.000021	158.339996	5.856475	0.6542
5	Air (10%) / Argon (9	Mix	0.017063	0.000021	558.033142	1.732866	0.6758
6	Air (10%) / Krypton (	Mix	0.009743	0.000023	276.130402	3.493234	0.6571
7	Air (10%) / Xenon (9	Mix	0.006217	0.000021	178.626038	5.400045	0.6125
1001	Air_EN673	Pure	0.024960	0.000018	1008.000000	1.292171	0.7112
1002	Argon_EN673	Pure	0.016840	0.000022	519.000000	1.781832	0.6669
1003	Krypton_EN673	Pure	0.009000	0.000024	245.000000	3.737796	0.6533
1004	Xenon_EN673	Pure	0.005330	0.000022	158.000000	5.856475	0.6539
1005	Air (10%) / Argon (9	Mix	0.017591	0.000021	555.463989	1.732865	0.6719
1006	Air (10%) / Krypton (	Mix	0.010120	0.000024	273.223907	3.493234	0.6405
1007	Air (10%) / Xenon (9	Mix	0.006434	0.000022	178.339569	5.400045	0.6111

Figure 1-1. Export the special EN gases into the Gas Library from the "EN673 gasses.mdb" gases library.

Environmental Conditions:

Also, when making the glazing system in WINDOW, set the environmental conditions to CEN (predefined in the Environmental Conditions library) with the following characteristics:

- U-factor: Inside
  Inside Air Temperature = 20 ° C
  Model = Fixed combined coefficient
  Combined Coefficient= 3.6 + (4.4 * ε / 0.837) W/m²K

  where
  3.6 = convective component of the combined coefficient
  (4.4 * ε / 0.837) = radiative component of the combined coefficient
  ε = Emissivity of the glass surface facing the inside condition.

- U-factor: Outside
  Inside Air Temperature = 0 ° C
  Model = Fixed combined coefficient
  Combined Coefficient= 23.00 W/m²K

- SHGC: Inside
  Inside Air Temperature = 25 ° C
  Model = Fixed combined coefficient
  Combined Coefficient= $3.6 + (4.4\cdot{*}\ \varepsilon / 0.837)$W/m^{2}K

  where
  3.6 = convective component of the combined coefficient
  $(4.4 * \varepsilon / 0.837)$ = radiative component of the combined coefficient
  ε = Emissivity of the glass surface facing the inside condition.

- SHGC: Outside
  Inside Air Temperature = 30 ° C
  Direct Solar Radiation = 500 w/m2
  Model = Fixed combined coefficient
  Combined Coefficient= 23 W/m^{2}K

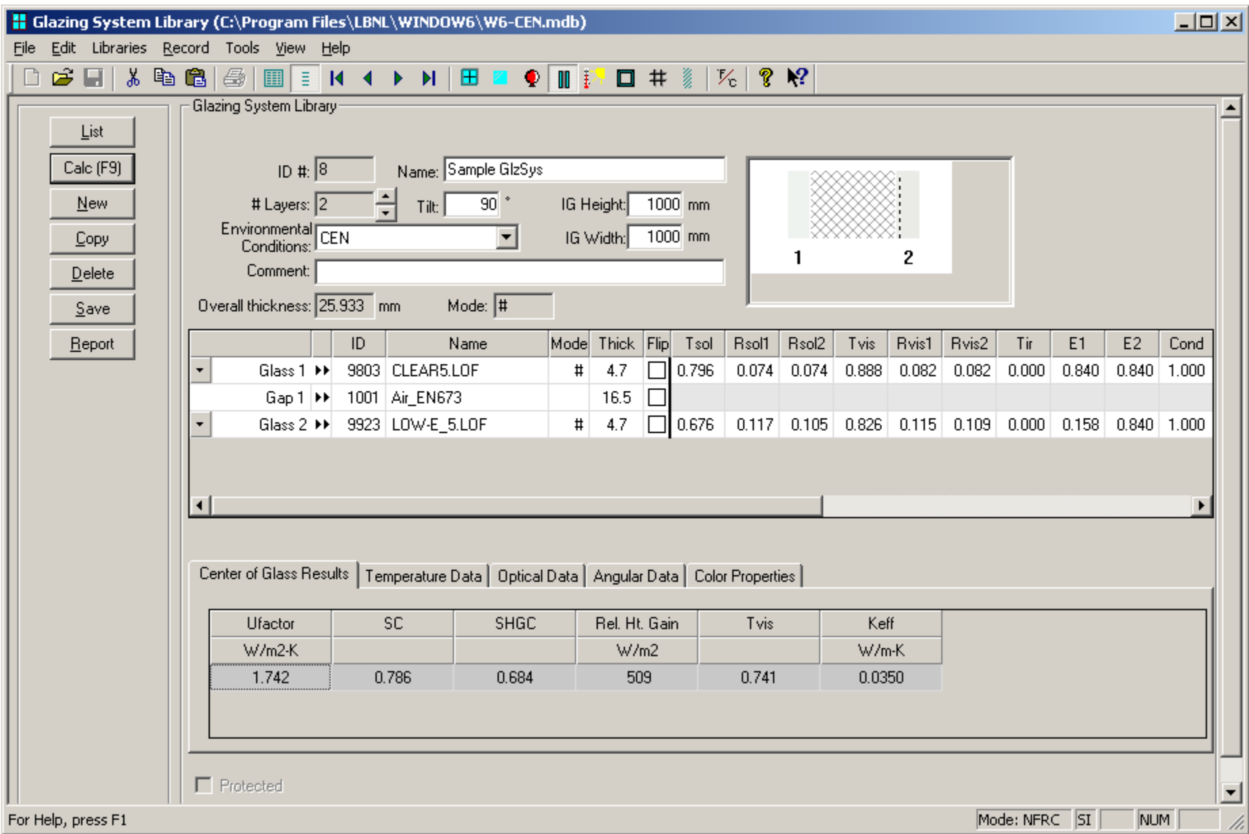


Figure 1-2. In WINDOW, make the glazing system and define the Boundary Conditions as "CEN"

1.2.2. THERM -- Frame and Edge of Glazing:

Frame and edge of glazing calculations are done according to ISO/EN 10077-2. When using the THERM program to model frames and edge of glazing according to this standard, the modeling is a two step process:

- Model the frames with the actual glazing/spacer configuration
- Model the frames with a Calibration Panel in place of the glazing/spacer elements

Model the frames with the actual glazing/spacer configuration

The following steps need to be performed to accomplish frame and edge of glazing modeling:

1. Draw the frame geometry.
2. Frame Cavity definitions:
   (defined in the Material Library):

   - Frame Cavity,CEN Simplified
     This Frame Cavity is already defined in the THERM 6 Material Library. It has the following characteristics:
     Material type= Frame Cavity
     Radiation Model = Simplified
     Cavity Model = CEN
     Emissivities for Side 1 and Side 2 = 0.9
   - Frame Cavity – CEN Slightly Ventilated
     This Frame Cavity must be defined in the THERM 6 Material Library, with the following characteristics:
     MaterialType =Frame Cavity
     Radiation Model = Simplified
     Cavity Mode = CEN (slightly ventilated)
     Emissivities for Side 1 and Side 2 = 0.9
3. Fill all of enclosed frame cavities with the “Frame Cavity – CEN Simplified”
4. Follow the rules in the NFRC THERM 5.2 / WINDOW 5.2 Simulation Manual, Section 6.3.7, “Slightly Ventilated Exterior Cavities” for information on how to determine which cavities should be set to CEN Slightly Ventilated.

5. Define boundary conditions. There are three types of boundary conditions:

   - CEN – Indoor
     Model = Simplified
     Temperature= 20^o C
     Color = variant of Red (optional)
     Film Coefficient= $3.6 + (4.4 * \varepsilon / 0.90)$ W/m^{2}K

     where
     3.6 = convective component of the combined coefficient
     $(4.4 * \varepsilon / 0.90)$ = radiative component of the combined coefficient
     ε = Emissivity of the glass surface facing the inside condition.

   - CEN – Indoor Reduced Radiation
     Model = Simplified
     Temperature= 20^o C
     Color = variant of Red, different than above (optional)
     Film Coefficient= $3.6 + (1.4 * \varepsilon / 0.90)$ W/m^{2}K

     where
     3.6 = convective component of the combined coefficient
     $(1.4 * \varepsilon / 0.9)$ = radiative component of the combined coefficient
     ε = Emissivity of the glass surface facing the inside condition.

   - CEN – Outdoor
     Model = Simplified
     Temperature= 0^o C
     Film Coefficient= 23.00 W/m^{2}K
     Color = variant of Blue (optional)

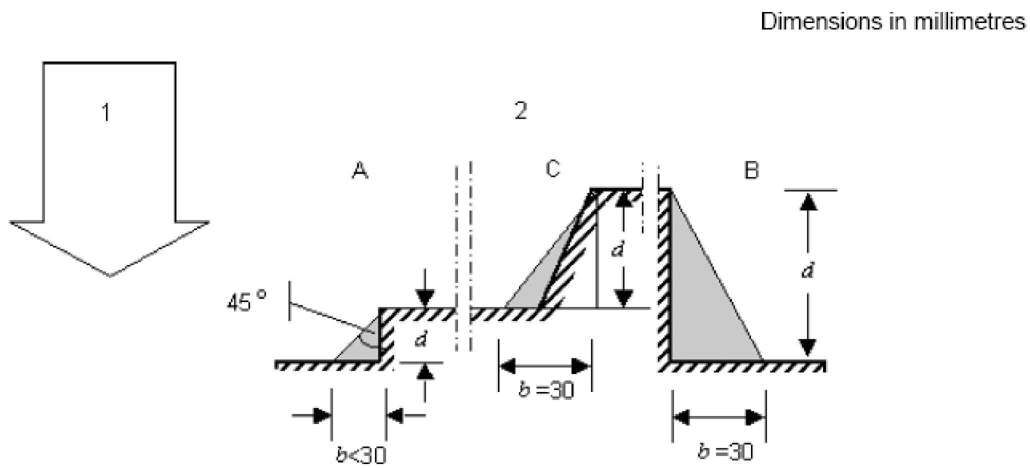
6. Import the glazing system defined in WINDOW 6 (which was modeled with the CEN 673 algorithm option activated) in the normal manner and draw the spacer

   The Glazing height is 190 mm, and the edge of glazing is equal to this entire length, so set both Edge of Glass Dimension and Glazing System Height to 190 mm.

   Set the Exterior Boundary Conditions to "CEN- Outdoor" and the Interior Boundary Conditions to "CEN-Indoor".

7. Create new points to accommodate reduced radiation boundary conditions. Reduced radiation boundary conditions exist only on Indoor side and it applies to facing segments in a corner, less then 30 mm. They are applied equally to facing sides, using right angle triangle rule with 45º angles (i.e., equal side right angle triangle). For additional details on the application of reduced radiation boundary condition see ISO/EN 10077-2.

   Set these boundary segments to the CEN-Indoor Reduced Radiation" boundary condition



Key

1 Direction of heat flow
2 Internal surface

Figure 1-3. In Schematic representation of surfaces with an increased surface resistance due to a reduced radiation/convection heat transfer

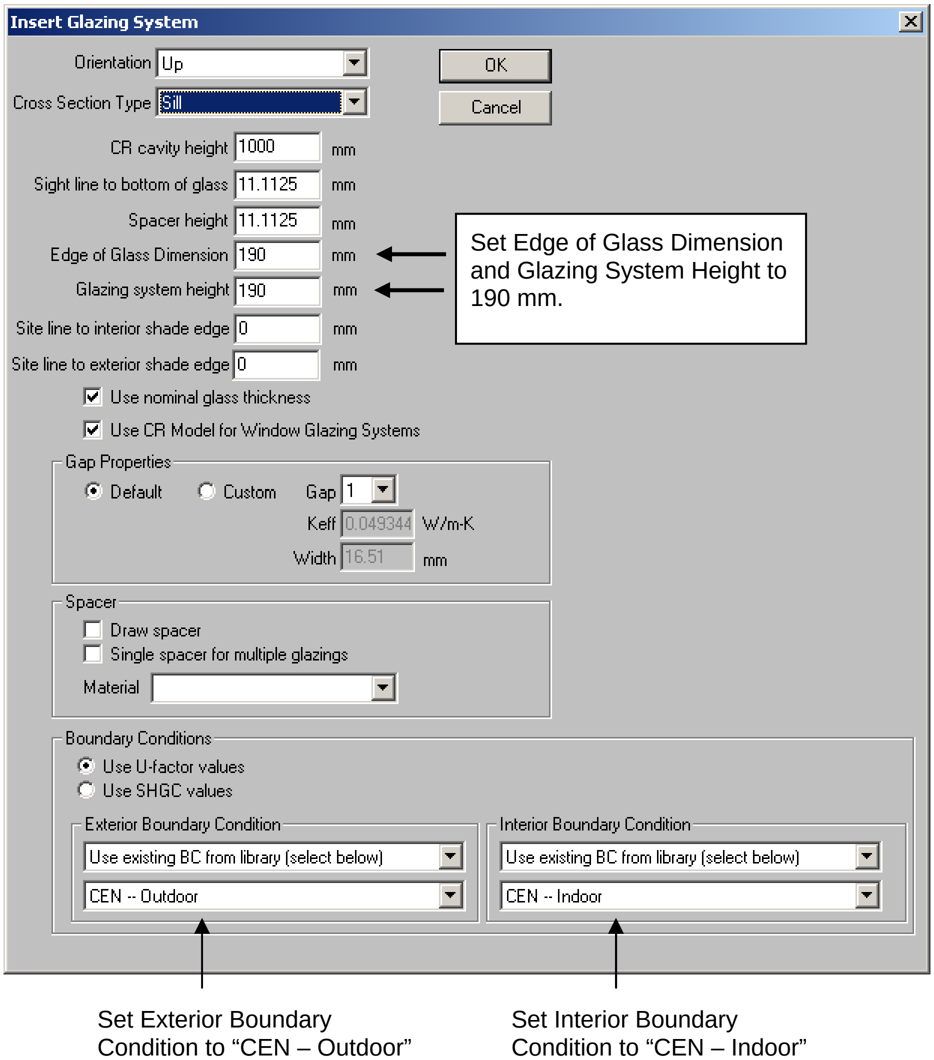


Figure 1-4. In THERM, insert the glazing system using CEN criteria for Edge of Glass Dimension, Glazing System Height, and Boundary Conditions.

8. Set the boundary condition to “CEN – Outdoor” on all of outdoor surfaces (glazing and frame)

9. Set the remaining boundary conditions to “CEN – Indoor” on the indoor side, including the glazing and frame.

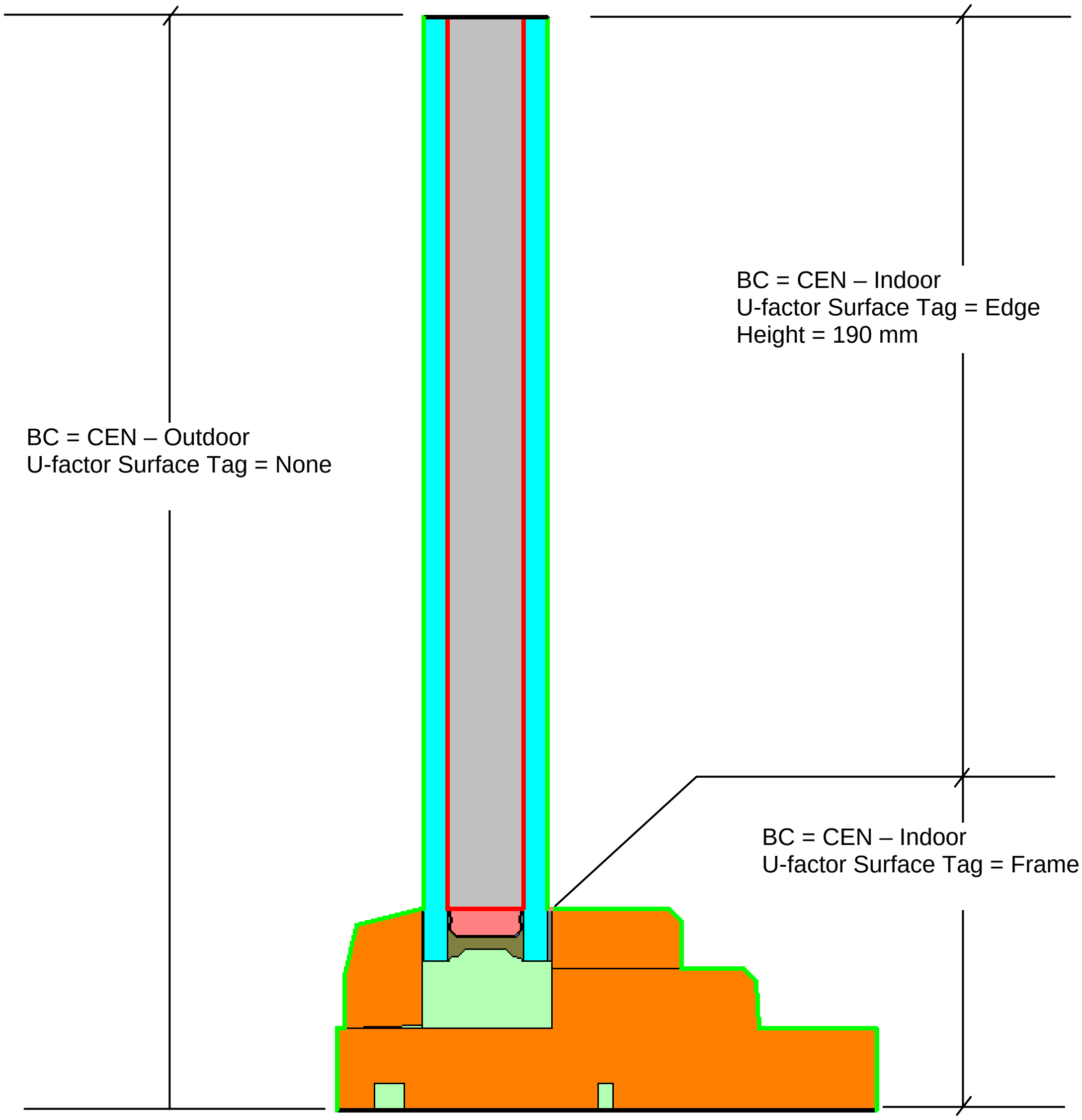


Figure 1-5. Boundary Condition definitions

10. Set U-factor Tags to “Frame” for all indoor frame surfaces and to “Edge” for all indoor glazing surfaces

11. Retain U-Factor Tag of “None” for the outdoor surfaces (both glazing and frame)

12. Save this model and perform the calculation
    (DCC – when I calculate this, I get a message in THERM 6 saying that CR can’t be calculated because there is not a radiation enclosure surrounding the interior glazing. So should we say to turn CR calc off when inserting the glazing system ?

Model the frames with a Calibration Panel in place of the glazing/spacer elements

Using the previously created model with the glazing system, createa new model with the calibration panel replacing the glazing system.

1. In the Material Library, create anew material called "CEN -- Calibration Panel"
   - Material Type = Solid
   - Conductivity = 0.035 W/mK
   - Emissivity = 0.90
   - Color = light yellow (optional)

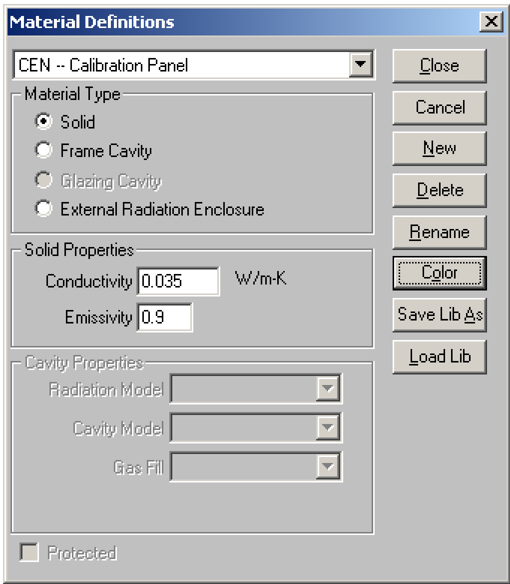


Figure 1-6. Defining the material for the Calibration Panel

2. Replace all the glazing and spacer polygons with the Calibration Panel material (delete the glazing system and substitute one polygon of the same dimensions).

3. Extend the top of calibration panel by 1 mm.

4. Insert a point on the indoor side of the Calibration Panel 1 mm from the top. In the U-factor Names Library, create a new U-Factor Tag called "Center of Glass", and apply that U-factor tag to the 1 mm segment at the top of the interior side of the Calibration Panel.

5. Define the rest of the U-factor surfaces in the same way as in glazing case

6. Save this model and perform calculation

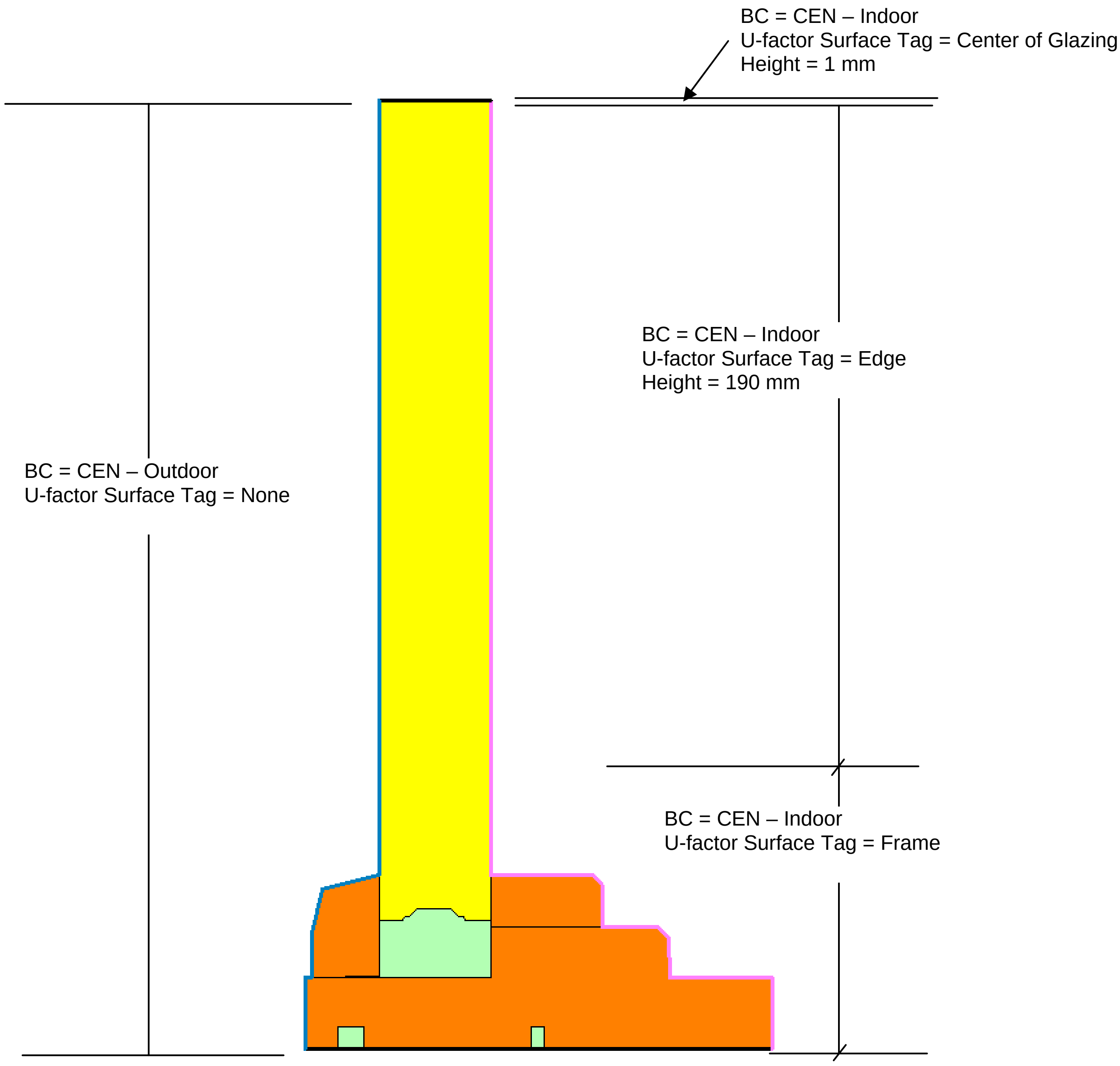
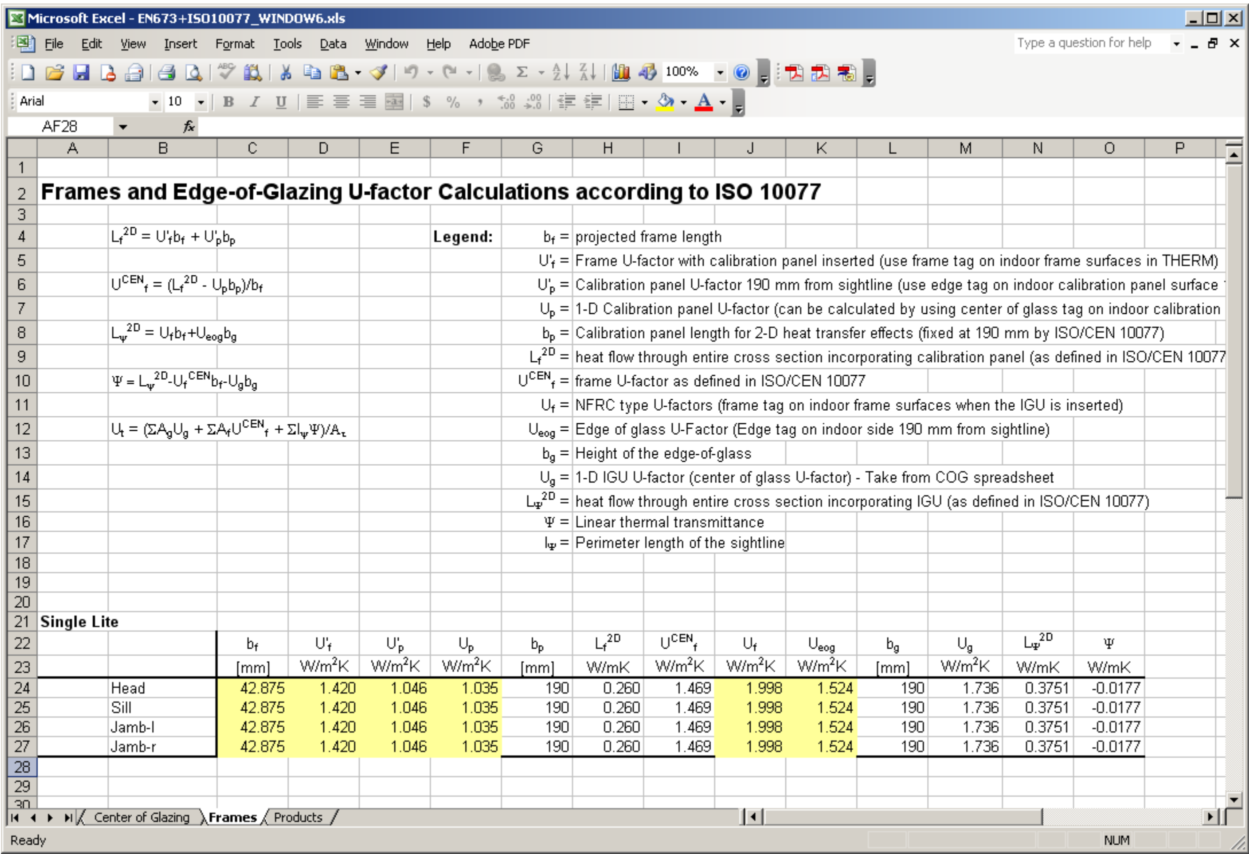


Figure 1-7. Defining the Boundary Conditions for the Calibration Panel

Calculate the Whole Product results in the EN673+ISO10077 spreadsheet

1. Open sheet "Frames" in "EN673+ISO10077" spreadsheet and select appropriate product for which these frame and edge of glazing sections are calculated. There are three types of products:
   - Single Lite
   - Dual Lite – Vertical
   - Dual Lite – Horizontal



	b_f [mm]	U'_f W/m²K	U'_p W/m²K	U_p W/m²K	b_p [mm]	L_f^{2D} W/mK	U^{CEN}_f W/m²K	U_f W/m²K	U_{eog} W/m²K	b_g [mm]	U_g W/m²K	L_Ψ^{2D} W/mK	Ψ W/mK
Head	42.875	1.420	1.046	1.035	190	0.260	1.469	1.998	1.524	190	1.736	0.3751	-0.0177
Sill	42.875	1.420	1.046	1.035	190	0.260	1.469	1.998	1.524	190	1.736	0.3751	-0.0177
Jamb-l	42.875	1.420	1.046	1.035	190	0.260	1.469	1.998	1.524	190	1.736	0.3751	-0.0177
Jamb-r	42.875	1.420	1.046	1.035	190	0.260	1.469	1.998	1.524	190	1.736	0.3751	-0.0177

Figure 1-8. The Frames tab of the spreadsheet for calculation the Frame and Edge-of-Glazing U-factor according to ISO 1007 from the THERM and WINDOW results.

The cells highlighted in yellow are those that need to be filled in from the THERM and WINDOW results, as discussed below. The other cells are defaults based on the ISO/CEN 10077 documentation.

2. Open the Center of Glazing tab in the spreadsheet and input the following data

From WINDOW6 Glazing System Library:

"U_g" Center of glazing U-factor, calculated earlier in WINDOW 6.2 (see section 1.2.1).

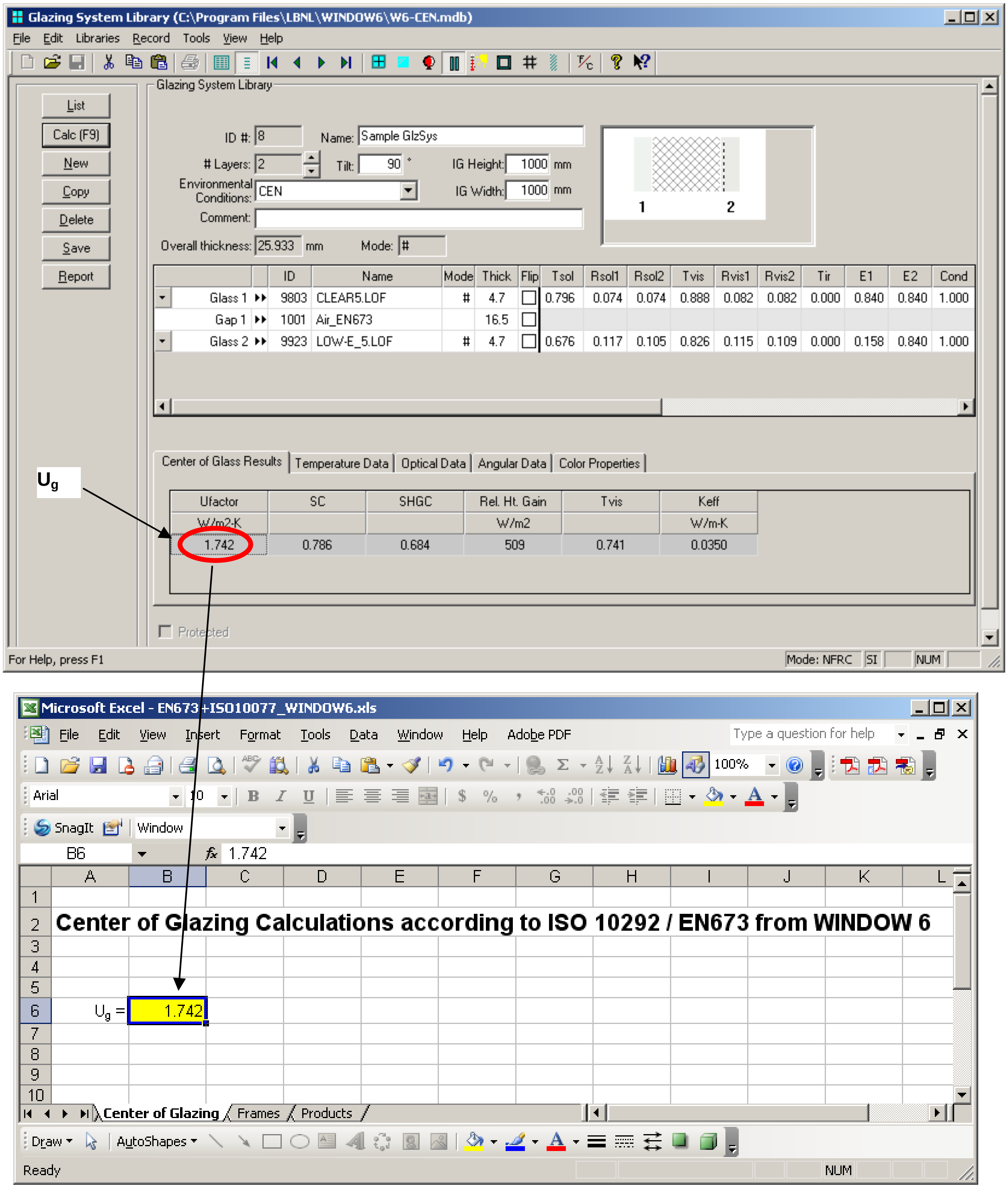


Figure 1-9. Glazing system results for Sample GlzSys, which are then entered into the spreadsheet.

3. Open the Frames tab in the spreadsheet, and input the following data for each frame member (from the THERM results):

From the model with the Glazing System and Spacer:

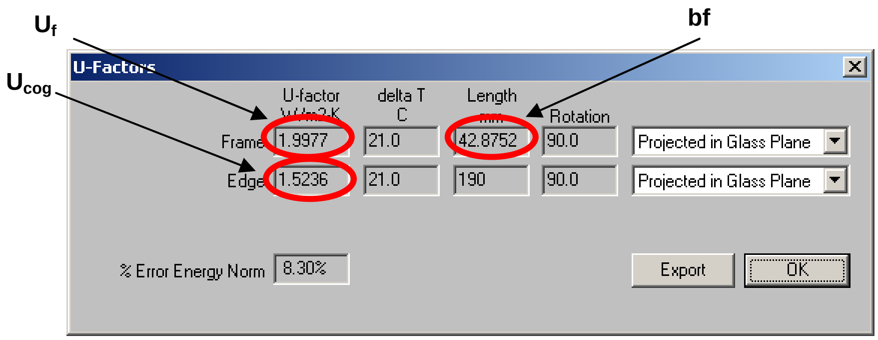


Figure 1-10. Results from the model with the actual glazing system.

"bf"	(Projected Frame Dimension) in THERM is Length (mm) for "Projected in Glass Plane" for Frame
"U_f"	Frame U-factor with glazing/spacer system inserted (use Frame U-factor tag on indoor frame surfaces in THERM)
"U_{eog}"	Edge of Glazing U-factor (use Edge U-factor tag on indoor glazing surface 190 mm from sightline in THERM).

From the model with the Calibration Panel:

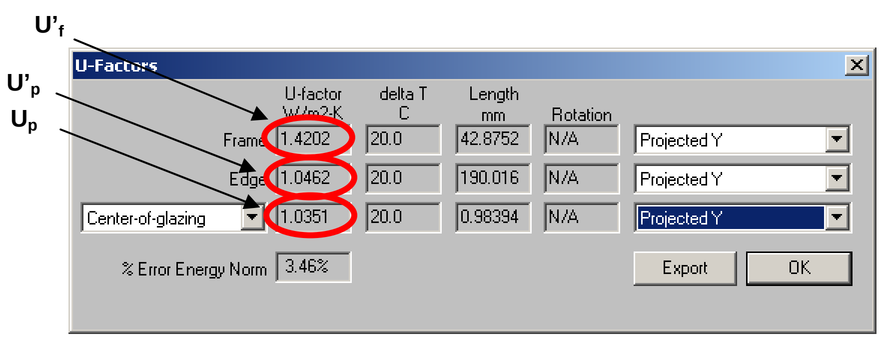
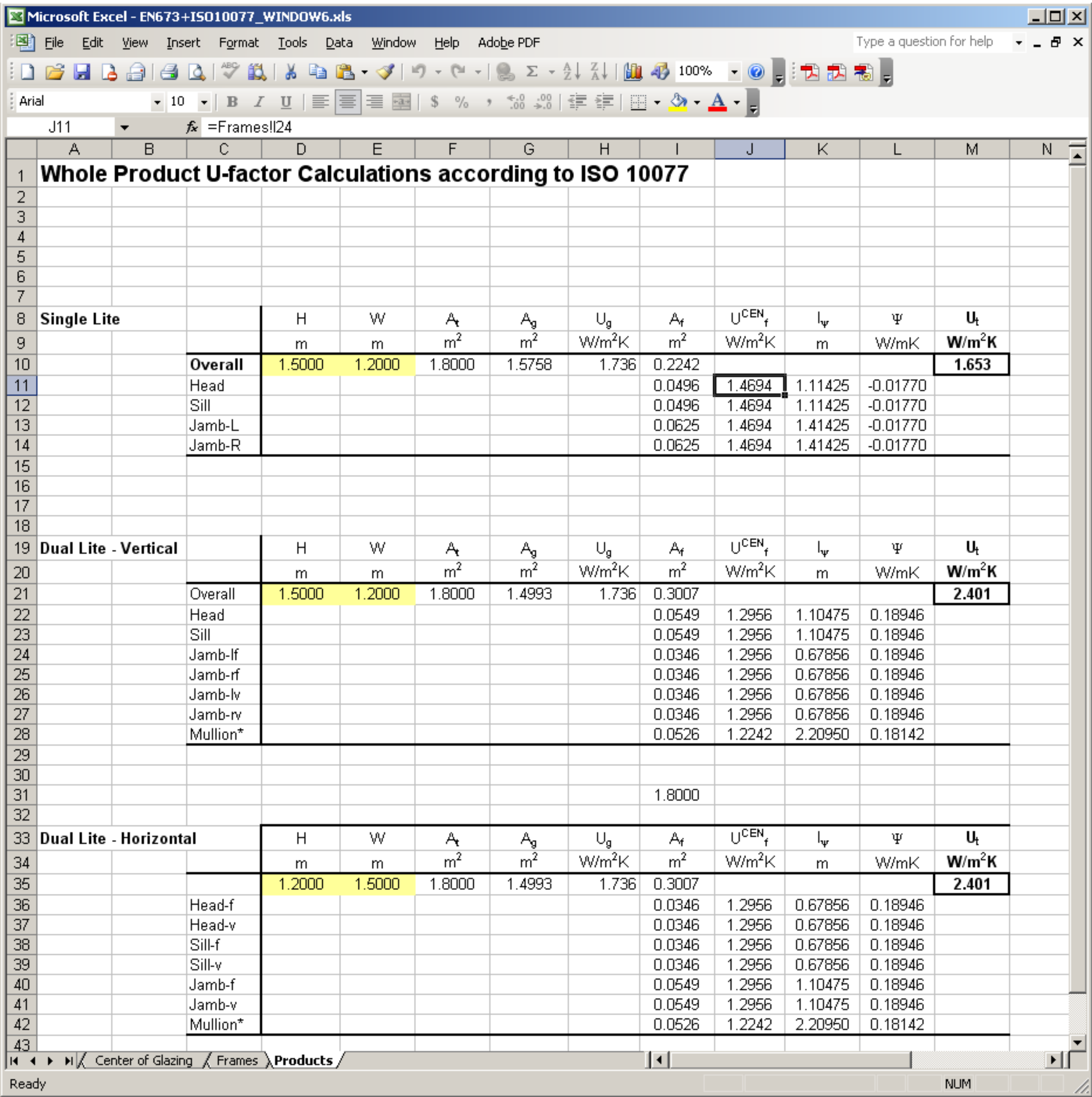


Figure 1-11. Results from the model with the calibration panel

"U'_f"	Frame U-factor (use Frame U-factor tag on indoor frame surfaces in THERM)
"U'_p"	Edge U-factor (use Edge U-factor tag on indoor calibration panel surface 190 mm from sightline in THERM).
"U_p"	1-D Calibration panel U-factor (can be calculated by using center of glass tag on indoor calibration panel surface starting at 190 mm from sightline and approximately 1 mm high in THERM)

4. Open sheet "Products" in "EN673+ISO10077" spreadsheet and select the appropriate product (the same product as in the "Frames" sheet). Input the following data (highlighted in yellow in the spreadsheet):
   - "H": Overall product height
   - "W": Overall product width

The results in terms of the U-factor for the whole product are displayed in the column "U_t".



	A–B	C	D	E	F	G	H	I	J	K	L	M
1	**Whole Product U-factor Calculations according to ISO 10077**											
2												
3												
4												
5												
6												
7												
8	**Single Lite**		H	W	A_t	A_g	U_g	A_f	U^{CEN}_f	l_ψ	Ψ	**U_t**
9			m	m	m^2	m^2	W/m^2K	m^2	W/m^2K	m	W/mK	**W/m^2K**
10		**Overall**	1.5000	1.2000	1.8000	1.5758	1.736	0.2242				**1.653**
11		Head						0.0496	1.4694	1.11425	-0.01770	
12		Sill						0.0496	1.4694	1.11425	-0.01770	
13		Jamb-L						0.0625	1.4694	1.41425	-0.01770	
14		Jamb-R						0.0625	1.4694	1.41425	-0.01770	
15												
16												
17												
18												
19	**Dual Lite - Vertical**		H	W	A_t	A_g	U_g	A_f	U^{CEN}_f	l_ψ	Ψ	**U_t**
20			m	m	m^2	m^2	W/m^2K	m^2	W/m^2K	m	W/mK	**W/m^2K**
21		Overall	1.5000	1.2000	1.8000	1.4993	1.736	0.3007				**2.401**
22		Head						0.0549	1.2956	1.10475	0.18946	
23		Sill						0.0549	1.2956	1.10475	0.18946	
24		Jamb-lf						0.0346	1.2956	0.67856	0.18946	
25		Jamb-rf						0.0346	1.2956	0.67856	0.18946	
26		Jamb-lv						0.0346	1.2956	0.67856	0.18946	
27		Jamb-rv						0.0346	1.2956	0.67856	0.18946	
28		Mullion*						0.0526	1.2242	2.20950	0.18142	
29												
30												
31								1.8000				
32												
33	**Dual Lite - Horizontal**		H	W	A_t	A_g	U_g	A_f	U^{CEN}_f	l_ψ	Ψ	**U_t**
34			m	m	m^2	m^2	W/m^2K	m^2	W/m^2K	m	W/mK	**W/m^2K**
35			1.2000	1.5000	1.8000	1.4993	1.736	0.3007				**2.401**
36		Head-f						0.0346	1.2956	0.67856	0.18946	
37		Head-v						0.0346	1.2956	0.67856	0.18946	
38		Sill-f						0.0346	1.2956	0.67856	0.18946	
39		Sill-v						0.0346	1.2956	0.67856	0.18946	
40		Jamb-f						0.0549	1.2956	1.10475	0.18946	
41		Jamb-v						0.0549	1.2956	1.10475	0.18946	
42		Mullion*						0.0526	1.2242	2.20950	0.18142	
43												

Figure 1-12. The Products tab of the spreadsheet for calculation the Whole Produce U-factor according to ISO 1007 from the THERM and WINDOW results.